

Design of an Expert System to Calculate Inheritance Shares Based on Islamic Law

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ABSTRACT

Death is an inevitable end that comes only when it comes. Part of the preparation to death is ensuring that one's assets are shared among the benefactors without rancor. Islam has defined the sharing formula of the properties of the deceased. The concept of inheritance from Islamic perspectives calls for no debate. The major challenge is how to get this knowledge to all in a more convenient and unambiguous form. This paper discusses the modeling of a rule-based expert system to calculate inheritance shares based on Islamic law.

Keywords: Rule-based, Expert system, Inheritance, Islamic law

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1. INTRODUCTION

Over the years, the computer has been put to numerous uses by various individuals and professionals. We find their applications in almost every sphere of life—particularly in fields where computations are required to be done at a very fast speed and where data is so complicated that the human brain finds it difficult to cope up with. Man's sojourn on this earth is for a limited period, for death is certain, and it saves no one from its grip – male and female, young and old alike. Upon the death of an individual, the deceased properties would have to be shared amongst his heirs. The death of a person brings about the transfer of most of his rights and obligations to persons who survive him [1]. Thus, Inheritance is the practice of passing on of the property, titles, debts, rights and obligations of an individual, upon his death to persons who survive him.

There are different ways by which inheritance is shared depending on sociological customs, laws of the land or religion [2]. These methods include patrilineal, matrilineal, primogeniture and ultimogeniture methods of passing down inheritance. Some cultures combine two or more of these methods. In the patrilineal system, only male children can inherit, while in the matrilineal system, only female children can inherit.

In the primogeniture system, all the property goes to the eldest child, while everything is left to the youngest child in the ultimogeniture system. Religiously however, only the Islamic and Jewish laws of Inheritance have been identified. The focus of this work is the Islamic law of inheritance. In Computer Science, expert system is a branch of Artificial Intelligence. According to An expert system is a computer system that emulates the decision-making ability of a human expert [3]. They are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. Expert systems are used to solve a wide range of problems such as making financial planning decisions, monitoring real time systems, and performing many services which previously required human expertise [4].

Islamic law referred to as Shari'ah is an Arabic word which literally means 'the path to be followed'. Technically, it refers to the moral code and religious law of Islam [1]. It is considered the infallible law of God, which derives its source from the Qur'an and the Sunnah of the Prophet of Allah, Muhammad (Peace Be Upon Him). Shari'ah deals with many topics addressed by secular law, including crime, politics, and economics, as well as personal matters such as sexual intercourse, hygiene, diet, prayer, and fasting.

Therefore, this paper seeks to examine the divine laws regarding the distribution of inheritance according to Islamic law and then design a rule-based expert system to calculate the individual inheritance share of the heirs to a deceased.

1.1 Statement of the Problem

One of the most important branches of the Islamic family law is that relating to inheritance. The Science of Miiraath in Shari'ah gives rules which guide as to who inherits and who is to be inherited, and what shares go to the heirs; thus Islam has formed a complete legal system for inheritance distribution [1]. However, the judges of the Shari'ah court are faced with challenges in dealing with the distribution of inheritance due to their concern for the satisfaction of all parties and the compliance with the Islamic law [2]. This is due to the fact that some people still hold on to their ancestral customs of inheritance distribution, regardless of its contradiction with Islamic law method in determining the distribution of inheritance [2]. Also, the calculations needed, in order to share the estate of a deceased amongst his heirs is quite complicated. Some of the difficulties encountered with this system of calculation include [2]:

- The calculation of inheritance according to Islamic law is quite complex, and this makes it quite brain tasking, especially when there are many heirs.
- Due to the infallibility of human beings, errors could be made in the calculations.
- Also, the manual system of calculating the inheritance makes it time consuming.

These problems can be solved with the development of an expert system, thereby automating the system of calculating the inheritance.

1.2 Objectives

Specifically, this work is aimed at reducing the difficulties and challenges faced by relatives of a deceased in passing on the deceased's property to the heirs by designing an expert system that would calculate these inheritance shares and specify the value of the share of each heir.

Thus, the objectives of this work include:

1. To study the Islamic laws regarding the distribution of inheritance.
2. To develop a rule based model based on the laws of inheritance according to Islamic law.

2. CONCEPT OF EXPERT SYSTEMS

Expert systems emerged as a branch of artificial intelligence, from the effort of AI researchers to develop computer programs that could reason as humans [5]. Previous author distinguishes two approaches when defining an expert system, which are the human/AI approach and the technology approach. Goodall's AI approach defines *an expert system as a computer system that performs functions similar to those normally performed by a human expert*.

He extends this definition to include the nature of an expert system, in other words, he includes how the expert system behaves. In the technology approach:

"An expert system is a computer system that uses a representation of human expertise in a specialist domain in order to perform functions similar to those normally performed by a human expert in that domain".

Expert systems have been found to be applicable in many areas of knowledge work such as:

- Diagnosis and Troubleshooting of Devices and Systems e.g. medical diagnosis and diagnosis of engineering systems.
- Planning and scheduling, e.g. airline flight scheduling and manufacturing process planning
- Configuration of Manufactured Objects from Sub-Assemblies
- Financial Decision Making
- Design and Manufacturing
- Knowledge Publishing, e.g. an advisor on appropriate grammatical usage in a text; and a tax advisor on tax strategy, tactics, and individual tax policy.
- Process Monitoring and Control, e.g. expert systems used in steel making and oil refining industries.

Other applications of expert systems include interpretation, prediction, debugging, and instruction [4], [5].

2.1 Architecture of Expert Systems

There are four internal and four external components of an expert system. The internal components are the knowledge base, working storage, user interface and inference engine; while the external components are the user, system engineer, knowledge engineer, and domain expert [7], [8], [9].

The Knowledge base is also known as the rule base. The effectiveness of an expert system is directly related to the quality of the knowledge it contains. The acquiring of expert knowledge is crucial and involves the gathering of information about a domain usually from an expert [5]. This is referred to as knowledge acquisition or knowledge engineering. Knowledge can be classified as **surface knowledge**, to put declarative and procedural knowledge into heuristics to solve a problem quickly; or **deep knowledge**, which involves fundamental knowledge of the domain including the definition, axioms, general laws, principles and casual relationships upheld by the knowledge. Surface knowledge is the basis for most common expert systems using production rules.

The working storage refers to the data which is specific to the problem being solved.

The user interface provides the conversation of the system with the user. It is responsible for posing the questions to the user, reading the user's reply and explaining the rules used to reach a conclusion. The explanation capability of an expert system, one of its most important features is realized in the user interface.

The inference engine is a computer program designed to produce reasoning on rules. It is the mechanism that performs the search and reasoning in rule-based systems. The inference engine is activated when the user initiates the consultation session. It finds the rules that matches the given facts, selects which rule to execute and executes the rule by adding the deduced fact to the working storage. The inference engine uses pattern matching to select the qualifying rules and the choice of which rule to fire is done by conflict resolution. The inference engine deduces facts or draws conclusions from the knowledge base based on the user input and the facts from the knowledge base and/or other sources. Three basic techniques are used when inferring facts or conclusions from the knowledge base which are forward chaining, backward chaining and hybrid chaining which uses both forward and backward chaining.

User is the individual who will be consulting with the expert system to get advice which would have been provided by the expert.

System engineer is the individual who builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine [6].

Knowledge engineer is the individual who encodes the knowledge of the domain expert in a declarative form that can be used by the expert system. Acquiring expert knowledge is a crucial component of knowledge engineering. This phase is difficult and time consuming. It is the process of gathering the relevant information about a domain, usually from an expert. Usually a computer program is compiled to incorporate all the knowledge of the domain.

Domain expert is the human expert who has the expertise needed to solve the problem the expert system at hand is intended to solve. The human expert, from whom the knowledge is acquired, needs to be a person that can effectively cope with the problem domain. Selection of the person is based on reputation. The expert should be available and willing to co-operate in the process of developing the expert system especially when acquiring the knowledge and testing the system. The expert must be able to communicate his expertise. The Islamic law of inheritance is called 'ilm ul-faraaid' or "the study of the injunctions (concerning inheritance)". In legal terminology, Miiraath means inheritance to be divided from the property of the deceased among his successors. The science of Miiraath in Shari'ah gives rules which guide as to who inherits and who is to be inherited, and what shares go to each heir [1]. What is left after the last needs of the deceased have been satisfied, namely after the payment of funeral expenses and the discharge of his obligations and debts, is to be distributed according to the law of Miiraath as defined in the Qur'anic injunctions.

Table 1: Prescribed shares of heirs according to the Qur'an

a/b	Individual	Conditions									
		U	BH	MOH	PA	HBH	FS	Fa	Mo	2MS	Notes
½	Husband		N								1
	Daughter	y			N						
	Son's daughter	y			N	n					
	Full sister	y	N	N	N						
	Paternal sister	y	N	N	N		N				
¼	Husband		Y								2
	Wives		N								2
⅙	Wives		Y								2
2/3	Daughters	n			N						2
	Sons' Daughters	n			N	n					2
	Full sisters	n	N	N	N						2
	Paternal sisters	n	N	N	N		N				2
1/3	Mother		N							n	3
	Maternal siblings	n	N	N							2,4
1/6	Father		Y								
	Mother		Y							y	5
	Paternal grandfather		Y					n			6
	Grandmothers								n		2,7
	Sons' daughters				N						2,8
	Paternal sisters				N						2,9
	Maternal sibling	y	N	N							

Table 2: Legend to table one:

Abbreviation	Explanation
U	The heir is <u>u</u> nique (no other similar individuals) in his (or her) class of relationship to the deceased.
BH	The deceased has <u>b</u> ran <u>ch</u> -heirs
MOH	The deceased has <u>m</u> ale <u>o</u> ri <u>g</u> in-heirs.
PA	The female heir has a <u>p</u> aternal <u>a</u> ssociate ('āsib), such as a son with the daughter, or a grandson with the granddaughter.
HBH	The female heir has <u>h</u> igher-ranking <u>b</u> ran <u>ch</u> -heirs, such as a daughter with the granddaughter.
FS	The deceased has <u>f</u> ull- <u>s</u> iblings (brothers or sisters).
2MS	The deceased has 2 or <u>m</u> ore <u>s</u> iblings (brothers and/or sisters) – half or full.
Fa	The <u>f</u> ather survives the deceased.
Mo	The <u>m</u> other survives the deceased.

3. CONCEPTUAL FRAMEWORK

According to Islamic law, Inheritance reaches an heir via two routes, fard or tā'sib [6].

3.1 FARD (Prescription)

The prescribed shares are the specific allocations determined in the Qur'an or Sunnah. They are one-half ($\frac{1}{2}$), one-third ($\frac{1}{3}$), one-fourth ($\frac{1}{4}$), one-sixth ($\frac{1}{6}$), one-eighth ($\frac{1}{8}$), and two-thirds ($\frac{2}{3}$). They hold for various individuals based on the fulfillment of certain conditions.

Notes to Table One:

1. The only case where there would be more than one-half ($\frac{1}{2}$) share is for the deceased to be survived by a husband and one sister.
2. The share for 2 or more of the same (ex., 2 wives, 4 daughters, 3 paternal sisters, etc.) is equally divided among them.
3. A special case is when, in addition to the mother, the deceased is survived by a father and a spouse. In such case the mother receives $\frac{1}{3}$ of the remainder.
4. Maternal siblings have the special qualities:
 - 1) Both the males and females equally share a $\frac{1}{3}$.
 - 2) They cause their mother's share to drop from $\frac{1}{3}$ to $\frac{1}{6}$.
5. Only one of the two conditions (BH and 2MS) must hold for the mother to receive $\frac{1}{6}$.
6. A grandfather may be an heir provided that there is no female link between him and the deceased. Thus, a mother's father, for example, cannot be an heir. The mother of such a grandfather cannot be an heir either. In the father's absence, the grandfather takes his position – except when the deceased is survived by full or paternal siblings. In the latter case, the grandfather shares with the siblings the residual estate (after removing the prescribed portion). His share is the better if $\frac{1}{3}$ and equal division with the siblings. But should never be less than $\frac{1}{6}$ of the full estate.

7. Also, there should not be a nearer grandmother surviving the deceased.
8. Also, one of the heirs must be a higher-ranking daughter or son's daughter inheriting $\frac{1}{2}$. The reason for this is that, in the absence of brothers, the deceased's daughters receive $\frac{2}{3}$ of the estate. If, however, the deceased is survived by only one daughter (and no sons), in addition to sons' daughters (and no grandsons), the daughter receives $\frac{1}{2}$, and the granddaughters share $\frac{1}{6}$, so that the total would be $\frac{2}{3}$.
9. Also, one of the heirs must be a full sister inheriting $\frac{1}{2}$. This is similar to the previous case.

3.2 Tā'sib

Tā'sib is an Arabic word which comes from the verb 'usbah, which means "clan; paternal relations; agnates". An individual inheriting through tā'sib is called 'āsib. Thus, tā'sib arises from kinship relationships. There are three forms of tā'sib[6]:

- * Independent tā'sib
- * Tā'sib by association
- * Tā'sib by joining with others

3.3 Independent tā'sib (for males)

Independent tā'sib applies to all of the male heirs, except the husband and maternal brother. An independent 'āsib may have one of the following situations:

- 1) If he is the deceased's only survivor, he takes all of the estate. For example, if a deceased is survived by only one son.
- 2) If there are survivors with prescribed shares, they are given their share first, and the 'āsib takes the residual of the estate. For example, of a deceased man is survived by a wife and a son, the wife receives $\frac{1}{8}$ by "prescription" while the son receives the remaining $\frac{7}{8}$ by "tā'sib".
- 3) If the prescribed shares cover all of the estate, the 'āsib drops from heirship. For example if a deceased woman is survived by a husband, mother, maternal brother, ad paternal uncle. The husband receives $\frac{1}{2}$,

the mother receives $1/3$, and the maternal brother receives $1/6$. This covers all of the estate, causing the paternal uncle to drop from heirship.

There are two exceptions to this rule: the sons and the father (or grandfather) cannot be cut off by the heirs with prescribed shares.

3.4 Tā'sib by association (for females)

This form of tā'sib applies only to the following female individuals:

Table 3: Tā'sib by Association.

Relationship	Condition
Daughters	The deceased is also survived by sons.
Sons' daughters	The deceased is also survived by sons' sons of equal rank to the daughters (or lower ranking great grandsons in absence of sons' sons).
Full sisters	The deceased is also survived by full brothers
Paternal sisters	The deceased is also survived by paternal brothers.

In the above cases, the shares are divided such that a male receives twice as much as a female. Thus, the females switch from heirs by prescription to heirs by tā'sib.

3.4 Joint tā'sib (for sisters)

Joint tā'sib has two forms:

Table 4: Joint tā'sib

Relationship	Condition
Full sisters	The deceased is also survived by daughters and/or sons' daughters.
Paternal sisters	

For example, if a deceased is survived by a daughter and two full sisters, the daughter receives her prescribed $1/2$, and the sisters divide the residual estate ($1/2$) by tā'sib. Also, if a deceased is survived by two daughters and a paternal sister, the daughters receive their prescribed $2/3$, and the sister receives the residual estate ($1/3$) by tā'sib. Also, if a deceased is survived by a daughter, a son's daughter, and two full sisters; the daughter receives $1/2$, the son's daughter receives the rest of $2/3$, which is $1/6$, and the remaining $1/3$ is shared equally by the two sisters. It should be noted that the daughters or son's daughters receive their prescriptions regardless of the presence of sisters. Also, when a full sister has joint tā'sib, she would cut off anyone who would otherwise be cut off by a full brother. This also applies to paternal siblings.

3.5 Hajb

Hajb is the process of cutting off a person from heirship. It could be total or partial. Total hajb occurs when the existence of some individuals entirely cuts off others from heirship. For example, if a deceased is survived by a father and a full brother, the father entirely cuts off the brother. Total hajb is applicable to all heirs except the parents, immediate offspring, and spouses. Partial hajb occurs when the existence of some individuals reduces the shares of others in the inheritance. Partial hajb is applicable to all heirs without exception. For example, when a deceased man is survived by a wife and a son, the wife's share is reduced from $1/4$ to $1/8$ because of the son. Also, if a deceased is survived by only one son, he takes the entire estate; but if he is survived by two sons, they would divide the estate in half, reducing the share of either one [6].

Therefore, the following rules can be deduced from the Islamic law of inheritance amongst others:

- A deceased's offspring share in his estate, a son receiving twice as much as a daughter. This is done after taking out any ordained shares.
- In the absence of immediate children, grandchildren replace them as heirs.
- If the deceased's offspring are two or more females (and no males), they receive two-third of the estate, which is then equally divided among them.
- If the deceased is survived by only one daughter (without brothers), she receives half of the estate. If in addition, there are granddaughters (but no grandsons), they share one-sixth, bringing the total for the female offspring to two-thirds.
- If the deceased is survived by any offspring, the parents receive one-sixth each.
- If the deceased has no offspring, but is survived by brothers or sisters – full, paternal or maternal, the mother receives one-sixth. The father's share is determined differently.
- If the deceased is neither survived by offspring nor siblings, the mother receives one third of the residual estate after taking out any prescribed shares.
- A husband receives half of his deceased wife's estate if she is not survived by any offspring, immediate or grandchildren, from him or from previous husbands. Otherwise, he receives one-fourth.
- A wife receives one-fourth of her deceased husband's estate if he is not survived by any offspring, immediate or grandchildren, from her or from other women. Otherwise, she receives one-eighth. If the deceased is survived by more than one wife (the maximum is four), these shares are divided equally among them.
- If the deceased has neither parent nor offspring, but has a maternal brother and/or sister, each of them receives one-sixth, and if they are more than two, they all share one-third.

- If the deceased has neither parent nor offspring, but has only one full or paternal sister, she receives half of the estate.
- If the deceased has neither parent nor offspring, but has two or more full or paternal sisters, they all share two-third equally.
- If the deceased has neither parent nor offspring, but has only one full or paternal brother, he receives all of the estate.
- If the deceased has neither parent nor offspring, but has a mixture of full and paternal brother and sisters, the whole estate is divided among them, giving a male twice as much as a female.

These rules are modeled into a rule base which serves as the knowledge base of the expert system.

4. DISCUSSION AND CONCLUSION

The passing on of the property of a deceased to his/her heirs as an important aspect of human life; for the reality is that man lives on earth, struggle hard, and amass wealth only for one thing – to die. Islam is not just a religion, but a way of life; which has not left any aspect of the human life without giving guidelines as to how they should be conducted. This also includes instructions as to how the wealth of a deceased should be distributed.

Since the main goals of computing are to increase the speed at which tasks are done, increase efficiency, and reduce human effort. Therefore, this work is focused on saving time and energy as well as increasing efficiency in relation to the calculation of inheritance shares according to Islamic law.

In this work, we became familiar with the basic concepts applying to expert systems. Also, we were exposed to the fundamentals of inheritance sharing according to the Islamic law. From this knowledge, we were able to extract the various rules used in calculating inheritance according to Islamic law, which was then used to model a rule base for the design of the expert system.

In conclusion, efforts can be made towards the implementation of this design. Also, since this work only considers the Islamic laws of inheritance; further research may examine the Jewish law of inheritance as well.

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AUTHOR'S BRIEF

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